



# Are rises in Electro-Magnetic Field in the human environment, interacting with multiple environmental pollutions, the tripping point for increases in neurological deaths in the Western World?



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## ABSTRACT

Whilst humans evolved in the earth's Electro-Magnetic-Field (EMF) and sun-light, both being essential to life but too much sun and we burn. What happens if background EMF rise to critical levels, coinciding with increasing environmental pollutants?

Two of the authors can look back over 50 clinical years and appreciate the profound changes in human morbidity across a range of disparate conditions – autoimmune diseases, asthma, earlier cancer incidence and reduced male sperm counts. In particular have been increased autism, dyslexia, Attention Deficit Hyperactivity Disorder and neurological diseases, such as Amyotrophic Lateral Sclerosis, Multiple Sclerosis, Parkinson's Disease, Early Onset Dementia, Multiple System Atrophy and Progressive Supranuclear Palsy. What might have caused these changes-while genetic factors are taken as given, multiple environmental pollutants are associated with neurological disease although the mechanisms are unclear. The pace of increased neurological deaths far exceeds any Gompertzian explanation - that because people are living longer they are more likely to develop more age-related problems such as neurological disease.

Using WHO global mortality categories of Neurological Disease Deaths (NDD) and Alzheimer's and Dementia deaths (Alz), updated June 2018, together they constitute Total Neurological Mortality (TNM), to calculate mortality rates per million for people aged 55–74 and for the over-75's in twenty-one Western countries.

Recent increases in American people aged over-75's rose 49% from 1989 to 2015 but US neurological deaths increased five-fold. In 1989 based on Age-Standardised-Deaths-Rates America USA was 17th at 324 pm but rising to 539 pm became second highest.

Different environmental/occupational factors have been found to be associated with neuro-degenerative diseases, including background EMF. We briefly explore how levels of EMF interact upon the human body, which can be described as a natural antennae and provide new evidence that builds upon earlier research to propose the following hypothesis.

Based upon recent and new evidence we hypothesise that a major contribution for the relative sudden upsurge in neurological morbidity in the Western world (1989–2015), is because of increased background EMF that has become the tipping point-impacting upon any genetic predisposition, increasing multiple-interactive pollutants, such as rises in petro-chemicals, hormone disrupting chemicals, industrial, agricultural and domestic chemicals. The unprecedented neurological death rates, all within just twenty-five years, demand a re-examination of long-term EMF safety related to the increasing background EMF on human health. We do not wish to 'stop the modern world', only make it safer.

## Introduction

### The hypothesis

It is an evolutionary fact that humans evolved within the Earth's

constant Electro-Magnetic-Field (EMF) and the sun's radiation which are essential to life. If there is too much sun, we burn but what if there is too much EMF?

We hypothesise that over the last 25 years increases in background Electro-Magnetic-Fields within the human environment, impacting

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upon the extant and rising multiple interactive-environmental pollutants is the Tipping Point for the accelerating increases in neurological deaths in the Western world [1–13]. For example, impacting on rising problems of air pollution, on what has been described as the neuro-inflammation hypothesis [14,15], whilst increased background of EMF are increasingly linked to both neurodegenerative disease and leukaemia, both associated with oxidative stress [16].

To make the case we need to look back at changing environmental pollutants and think across disciplines to consider apparently unconnected changes in human morbidity. Two of the authors have the advantage of being able to look back over 50 clinical years and can appreciate the profound changes that have occurred. What is often difficult to grasp is how recent are changes in the world environment. There has been an explosive development in a wide range of chemicals that have been employed by human in the relentless pursuit of mastering our environment.

The digital world that now surrounds us with new levels of Electro-Magnetic Fields [EMFs] and it is the magnetism that might be the problem. Many environmentally linked diseases often need 20 or more years to develop [17,18], so as the digital world is still a relatively a new phenomenon, the possible twenty years needed for pathological effects problems of raised EMF is perhaps beginning to emerge?

The first major wake-up call of the impact of environmental pollution upon human morbidity was Rachel Carson's 1968 'Silent Spring'. She highlighted the damage to wild-life by environmental degradation and alerted us to the fact that human beings are not exempt or immune to environmental pollutants. The slow response to emerging scientific alarm bells was seen in the reluctant acceptance of the problem with asbestos, which has led to today a growing epidemic of people entering their sixties with asbestos related diseases and with the previously assumed neutral organophosphates [17–19]. The recent Volkswagen scandal who hid the extent of diesel particulates shows we cannot always trust even the most prestigious companies to acknowledge inadvertent negative impacts on human health of economic activity.

We will ignore notable changes in human morbidity such as rises in autoimmune disease, allergies, falling sperm counts but focus upon conditions which can be said to be broadly neurologically related.

Attention Deficit Hyperactivity Disorder (ADHD) which was virtually unheard of until the 1980's. It might well be an early soft-neurological sign but reflects undoubted change. It was described as 'minimal cerebral dysfunction' and from 1963 onwards it took 20 years to have a 100 papers on the medical data base 'medline'. Re-defined as ADHD in 1987, from January to September 2018 there were 700 papers, from across the world.

Autism, rare before the 1970's, initially being described as a primarily psychological disorder in children of 'refrigerator parents'. Now widely recognised and every Western country has an Autistic Society, with an estimated 700,000 British people on the autistic spectrum with a projected 20 million people world-wide [20]. Whilst this may be to do with a greater willing to make the diagnosis, does this really explain the enormous rise in numbers?

Another 'ambiguous' condition is Chronic Fatigue Syndrome (CFS) or Myalgic Encephalomyelitis (ME) and is still debatable whether it is a 'functional' rather than neurological disorder. Two other new but controversial diagnostic categories are Electromagnetic Hypersensitivity (EHS) and Multiple Chemical Sensitivity (MCS). The first paper on medline for EHS was in 2005 but in the last three years there were 223. In regard to MCS the first paper was in 1975 and only a second study by 1988 but in 2018 there were eight such papers.

If ADHD, Autism-Asperger spectrum, Dyslexia and ME/CFS, all initially ascribed to children but now diagnosed in adults, are thought of as basically neurological disorders this raises the question are there environmental influences related to these increased 'neurological' conditions. Plus rises in the established conditions such as Motor Neurone and Parkinson's Diseases etc [1–16]?

It is hypothesised that the impact of Electro-Magnetic-Fields,

*interacting and impacting on top of genetic predisposition and extant and growing multiple environmental changes*, is the tipping point that triggers these unprecedented accelerating rises.

However, it has to be acknowledged that there are some inconsistent findings regarding EMF, as some have found no EMF link with neuro-pathology, or that EMFG has been therapeutic [21–27]. Alternative explanations, such as the Gompertzian hypothesis [28,29] and improved diagnosis [30] are sometimes used to suggest the rises in neurological morbidity are essentially an artefact.

The major artefact argument is the Gompertzian hypothesis that explains the raised incidence is because people are now living longer to develop aged-related disease, so it is argued that the increases mainly reflect improved longevity [28,29]. This hypothesis will be evidentially refuted in the course of this study.

#### *Clinical studies of incidence of neurological disorders*

We briefly explore human clinical level studies reporting rises in neurological diseases, especially Parkinson's Disease and Amyotrophic Lateral Sclerosis (ALS), designated Motor Neurone Disease in Europe. We have decided to exclude all animal studies, despite many results indicating possible aetiological EMF connections but there is always the question of transferability to humans. As will be shown, there are sufficient human clinical studies to support the EMF tipping point hypothesis.

A series of clinical type studies highlighted rises in a range of neurological disease such as ALS, could be described as epidemic [1–16], mainly in Western countries but reports from other continents are increasing [7–10] and rises in Parkinson's Disease adds to the growing burden upon services and families [4,13]. Another notable feature over the past decade is the rise in what might be considered the rarer neurological conditions such as Multiple System Atrophy and Progressive Supranuclear Palsy [31–35].

Nonetheless, it cannot be denied that having proportionally more elderly people might well be a minor factor, but when the extent of the changes, based on the latest WHO data, updated June 2018, this explanation fails to account for the increases [36].

A major challenge to the Gompertzian explanation is stalky challenged by evidence of the explosive rise in *early onset dementias* reported in the Western world and other continents [37–45]. Furthermore, in practice terms the Gompertzian explanation is at practical odds with important but different type of evidence found in the need for the British Parkinson's Society to establish a Young Persons section for their services, with people under-40's and a new British charity, Young Dementia UK that has many clients under 50 years old! It is when these conditions are juxtaposed together then the possible connections between the psychical and socio-psychological environments can be seen.

#### *New comparative international study*

Before considering the inter-related multiple causes of neurological conditions, and, addressing the central tenant that EMF might be the tipping point for the rises in neurological morbidity, we provide the very latest population-based analysis of neurological deaths. This builds upon our earlier epidemiological studies [11–13] but extrapolates further from the recently updated WHO data [36].

Table 1 shows the two WHO global neurological categories Nervous Disease Deaths (NDD) and Alzheimer & other Dementia (Alz) deaths in Age-Standardised-Death-Rates (ASDR) – in effect controlled for total population between baseline years 1989–912 and 2013–15, which combined gives a Total Neurological Mortality (TNM) rate per million (pm) of population [36].

The highest TNM was Finland at 911 pm, the USA 539 pm, the Netherlands and the UK 424 pm. Over the period 1989–2015 this represents rises of 161%, 196%, 128% and 67% respectively. The lowest

**Table 1**

Age-Standardised-Death-Rates for Neurological Disease Deaths (NDD) & Alzheimer Deaths (Alz) & Total Neurological Deaths (TND) both Sexes rates per million 1989–91 v2013–15. # NDD higher than Alz.

Country & Years 2014 & 1979 Ranks	NDD 1989–2015	Alzheimer 19879–2015	TND 1989–2015
1-1. Finland	118–458 #	231–453	349–911
Ratio Change	3.88	1.96	1:2.61
2-14. USA	110 #–238	72–301	182–539
Ratio Change	2.16	4.18	1:2.96
3-14. Netherlands	123 #–171	69–266	192–437
Ratio Change	1.39	3.86	1:2.28
4-3. UK	132–167	122–262	254–424
Ratio Change	1.26	2.15	1:1.67
5-6. Sweden	76–162	111–244	187–406
Ratio Change	1.99	2.22	1:2.17
6-2. Switzerland	154 #–168	127–228	281–396
Ratio Change 1995	1.09	1.80	1:1.41
7-18. Canada 2013–13	136 #–169	103–218	239–387
Ratio Change	1.24	2.12	1:1.62
8-7. Belgium 2011–13	211 #–188 #	148–187	359–375
Ratio Change	0.89	1.26	1:1.04
9-9. Norway 1986	112 #–170	92–204	204–374
Ratio Change	1.52	2.22	1:1.83
10-12. Denmark 1994–15	94 #–162	48–211	142–373
Ratio Change	1.72	4.40	1:2.63
11-5. Spain 1980	85–172	114–193	186–365
Ratio Change	2.02	1.69	1:1.96
12-11. Australia	107 #–163	76–199	183–362
Ratio Change	1.52	2.62	1:1.98
13-10. Ireland 2012–14	135 #–178	66–183	201–361
Ratio Change	1.32	2.77	1:1.80
14-4. France 2012–14	117 #–193 #	60–162	203–355
Ratio Change	1.65	2.70	
15-8. N. Zealand 2010–12	105 #–158	100–169	205–327
Ratio Change	1.50	1.61	1:1.60
16-13. Germany 1990–2015	96 #–123 #	44–120	140–243
Ratio Change	1.28	2.73	1:1.74
17-19. Italy	104 #–136 #	57–119	161–255
Ratio Change	1.31	2.09	1:1.58
18-19. Portugal 1980–2014	70 #–133 #	28–96	98–229
Ratio Change	1.90	3.43	1:2.34
19-16. Austria	96 #–132 #	28–49	124–181
Ratio Change	1.38	1.75	1:1.46
20-15. Greece	52 #–75 #	20–29	72–104
Ratio Change	1.44	1.45	1:1.44
21-21. Japan	42 #–66 #	24–37	66–103
Ratio Change	1.57	1.54	1:1.56

countries were Japan at 103 pm, Greece 104 pm, Austria 181 pm and Portugal 229 pm yet these rates are also equivalent to rises of 56%, 44%, 46% and 129% respectively, with an overall average rise for the 21 countries of 90% over the period, all controlled for population.

A perusal of the table shows that in the 1989–91 period seventeen countries had higher NDD rates than Alz but by 2013–15 only eight nations' NDD rates were higher than Alz although *both* death rates increased over the period.

A further challenge to the Gompertzian explanation [28,29], is shown in Table 2, which compares the increases in population of men and women aged 75 + juxtaposed against rises in the Elderly (75+) TNM rates from which to calculate a population and Total Neurological (TNM) time ratio.

The highest rate was Finland at 7204 pm but by 2013–15 had risen to 31,246 pm, which is 4.33 ratio of change, compared to only 66% rise in the 75+ population, yielding an odds ratio of 1:2.61. Followed by the USA at 18056 pm, with a five-fold 75+ TNM increase compared to a 49% rise in population yields a ratio of change of 1:3.59.

Other notable population to TNM ratios were Canada 1:4.89, Denmark 1:4.21, Sweden 1:3.40, Portugal 1: 3.25, Norway 1:2.97, Netherlands 1:2.77 and the UK 1:2.49 and six other countries had ratios greater than 1:1.50, only Belgium at 1:0.88 had greater population rises than TNM, and though Greece and Japan more than doubled their TNM

**Table 2**

Over-75's Population & Total Neurological Mortality rates per million 1989–2015. Ratio of change Population to TNM then Odds Ratios. Ranked by highest TNM.

Country	Population 1989	Ratio of Change	Rates TND	Ratio of Change	Odds Ratio
1-3. Finland 1989	0.281	1.66	7204	4.33	2.61
2015	0.467		31,246		
2-8. USA 1989	13.103	1.50	3355	5.38	3.59
2015	19.621		18,056		
3-4. UK 1989	3.98	1.30	4767	3.24	2.49
2015	5.19		15,438		
4-7. Netherlands	0.814	1.57	3420	4.35	2.77
1989	1.282		14,868		
2015					
5-10. Sweden	0.683	1.22	3322	4.15	3.40
1995	0.830		13,801		
2015					
6-2. Switzerland	0.471	1.43	7344	1.73	1.21
1989	0.675		12,693		
2015					
7-17. Canada 1989	1.296	1.82	1374	8.90	4.89
2013	2.357		12,235		
8-11. Spain 1989	2.142	2.01	3297	3.62	1.80
2015	4.298		11,920		
9-11. Norway	0.299	1.20	3297	3.56	2.97
1989	0.358		11,735		
2015					
10-6. France 1989	3.931	1.49	4227	2.64	1.77
2014	5.853		11,177		
11-15. Denmark	0.362	1.16	2279	4.88	4.21
1994	0.420		11,122		
2015					
12-5. Australia	0.744	1.98	4488	2.47	1.25
1989	1.496		11,064		
2014					
13-9. Ireland 1989	0.159	1.51	3329	3.25	2.15
2014	0.240		10,812		
14-1. Belgium	0.659	1.51	8101	1.33	1:0.88
1989	0.998		10,771		
2015					
15-13. New Zealand	0.152	1.74	3265	3.02	1.74
1989–2013	0.265		9844		
16-14. Italy 1989	3.678	1.79	2493	2.94	1.64
2015	6.595		7319		
17-16. Germany	5.549	1.52	1977	3.25	2.14
1990	8.459		6422		
2015					
18-17. Austria	0.527	1.43	1640	3.40	2.38
1989	0.752		5570		
2015					
19-19. Portugal	0.527	1.90	899	6.17	3.25
1989	1.003		5551		
2014					
20-20 Japan 1989	5.974	2.66	759	3.53	1.33
2015	15.896		2682		
21-18. Greece	0.608	1.90	1080	2.09	1.10
1989	1.158		2261		
2015					

over the period they had the next smallest population to TNM ratios, 1:1.10 and 1:1.33 respectively.

Though the Gompertzian explanation of these increases might have made some contribution but not at this rate or in such a relatively short time. Moreover, in 1989–91 the USA was 14th highest of the 21 countries but by 2013–15 were second highest in the Western world!

An indication of the speed of change in neurological deaths in the 55–74 year age band, which is *below the life-expectancy* of all the countries is given in Table 3, ranked by biggest increase in just the last 10 years.

Thirteen countries had rises of 20% and more over the decade, the biggest rises were in Greece 68%, Japan 50%, albeit starting from a low base and the Netherlands at 56%, with ten countries having rises

**Table 3**

Total Neurological Deaths both Sexes aged 55–74 rates per millions years 2005, 2010 and 2015% Change 2005 to 2015 Indicating Accelerating Change. Ranked by Biggest Increase.

Country & Final Year	2005	2010	2015	% Change
1. Greece	225	245	378	+68%
2. Netherlands	387	412	602	+56%
3. Japan	161	186	242	+50%
4. Germany	325	405	478	+47%
5. UK	449	496	653	+45%
6. Austria	263	304	366	+39%
7. Denmark	438	519	602	+37%
8. USA	541	621	713	+32%
9. Australia	385	400	504	+31%
10. Sweden	479	554	631	+31%
11. Finland	794	946	1006	+27%
12. N. Zealand 2013	394	474	475	+21%
13. Switzerland	445	516	536	+20%
14. Italy	386	413	460	+19%
15. Portugal 2014	374	369	432	+16%
16. Norway	500	534	566	+13%
17. Ireland 2014	479	470	521	+9%
18. Spain	485	467	505	+8%
19. Canada 2013	479	489	481	1%
20. Belgium	568	542	558	–2%
21. France 2014	485	457	433	–11%

of > 30%, including the UK at 45% and the USA at 32%, though there were slight falls in Belgium and France. In the first international comparison of changing patterns of neurological deaths which focused upon the 55–74 age band [11], when compared to later studies [12,13], it is clear these rates are increasing and accelerating as well as involving more countries as the years have unfolded.

To provide a policy and practice perspective, as rates are statistics but numbers are actual people. The numbers of people in Britain and America dying from a neurological disorder in the age-band 55–74 will illustrate the speed of change.

Between 1989 until 2015 the numbers of neurological deaths of people aged 55–74 in Britain went from 3518 to 5177 an effective 47% increase over the period. The numbers of Total Neurological Mortality in the UK rose from 27,419 to 90,535, equivalent to a 330% rise.

In the USA, the 55–74 age band numbers grew from 16,608 to 76,244, more than a four-fold increase. As to Total numbers America went from 68,071 to 409,217, a six-fold increase. It is questionable whether neurological services have increased in anything like these proportions.

What there can be little doubt about is that there is an epidemic rise in neurological deaths, outstripping any demographic or Gompertzian explanation, or due to neurological disease diagnosis becoming more ‘fashionable’ but surely not at the extent of these accelerating changes.

Therefore our hypothesis asks might the changed pattern of EMF in the human environment be the trigger/tipping point impacting upon of any genetic predisposition and multiple inter-acting environmental influences?

#### Some aetiological associations

This raises the question of what might be the cause of such changes? Evidence comes from studies that point towards multiple-interactive-environmental factors. A number of occupational groups have been associated with raised ALS [46–52]. With similar associations in regard to occupations and exposure to a range of chemicals and solvents in regard to Parkinson’s Disease [53–56]. Also there have been indications of background Electro-Magnetic-Fields been associated with various neurological conditions [14,54–59]. Although, as mentioned previously, some studies have shown that short term exposure to low level EMF can help improve memory in Alzheimer, and can assist healing of wounds, fractures and improve stroke patients [21–27].

#### Epigenetics

As with many pathologies there are degrees of under-lying genetic predisposition/vulnerability awaiting the environmental trigger, seen in the epigenetics of ALS with its familial and sporadic forms, interacting with genetic predisposition influenced by environment [60–66].

Some research is quite specific about broad environmental triggers interacting with a person’s genetic background, with such examples related to solvents, Electro-Magnetic-Field (EMF) and a range of natural products’ [18,48,52,54,66–68]. Bearing in mind the increase in early onset dementias, at unprecedented levels, the epigenetic influence is confirmed by a series of studies that show a degree of familial inheritance [38,40,42,67,68]. Finland has long had the highest rate of neurological pathology. With some studies showing a degree of familial origins, however, the extent of the recent changes supports the finding that increased rates of neurological morbidity are more sporadic than familial in origin [4,5,38,40–43,54,60–68]. Moreover, it should be remembered that the USA neurological death rate rose from being 14th highest to become second highest in the Western world.

A key paper comes from Finland that explored early onset dementia and interactive epigenetic factors, whose rate of increase far exceeds any possible inherent genetic or Gompertzian influences but indicates that the logical explanation of the environment in which rises in background EMF appears to have played a significant and perhaps tipping point to fuel the neurological epidemic [42,43,69].

#### EMF: impacting upon human neurology

The key question is how does EMF affect the brain and human neurology? After all the brain is essentially an electro-biochemical organ and electrical impulses operate the nervous system, so in one sense, the EMFs are unlikely to be ‘neutral’ on human neurology over time [14]. Moreover, human’s evolved in the earth’s magnetic field, whose flow can be seen by any compass, whilst sunlight is essential for life, yet too much damages or kills.

Whereas the increased background Electro-Magnetic-Field on people over the past two decades, with the remarkable increases in digital devices, raises the question are we beginning to see the negative health impact, especially over the last decade, similar to the delayed development of environmental based disorder with a twenty year lead-in, such as asbestosis and impact on the previously assumed neutral organophosphates [17–19].

The EMF comes from a range of social as well as domestic objects such as radar power with pulsed MHz and GHz signals, some for micro-seconds can be very high, whilst at a low domestic level wiring creates a EMF with harmonic spikes, which by taking a compass close to electric sockets produces observable but noticed magnetic field. Some authorities showed that an accumulating dose of GSM 900-MHz RE-EMF might have devastating effects on neural stem cells proliferation and neurogenesis, leading to differentiation and apoptosis [70–89].

From a recent study in Military Medical Research, the strength of the various EMF objects, with which most people come into frequent contact are as follows [81].

#### Domestic:-

FM Radio Antennas 80–800 MHz.  
Mobile Phones 453–1980 MHz.  
Microwave ovens 915–2450 MHz.  
Cordless phones 1800–1900 MHz.  
Bluetooth devices 2450 MHz.

Previously hairdryers produced seventeen times the ambient EMF but modern hairdryers have now been adapted to emit around 50–60 Mhz.

#### Locality:-



Mobile Phone base station 463–2170 MHz  
 Surgical equipment 2450 MHz.  
 Wireless Local Radio 2450–5000 MHz.  
 Radar 30–30,000 MHz (300 GHz).

Twenty-five years ago apart from FM radio antennas and domestic TV's and radio the sources of EMFs were not yet in general use! With such a major increase in background EMF can we really be sure of its neutrality? When illustrating changes to students and asking males to point to where they keep their mobile phones, mainly in their trouser pockets, means their gonads are being bathed in between 450 and 1900 Mhz, a totally new phenomena on human evolution but space precludes the possibility related to falls in male sperm counts [22]. Whilst, an early study showed that even at a low frequency such as 50-Hz this could influence sleep patterns [70], but crucially the EMF interacts at cell level and at chromosomal level [71–80].

Burke described in detail the magnetic phenomena on human neurology cellular and EMF interaction within the body [80]. Whilst, we have generally eschewed studies of the impact of EMF on animals, we need to acknowledge that even at very low frequencies on simple cell development, such as sea urchins, the impact make a dramatic effect on new cell development [81].

There are very large numbers and types of charged metallic particles in our bodies and brains. The magnetic fields and unpaired electrons that result from charged particle movements are part of the chemical bonds holding all matter together. These traverse a variety of paths and some will spin. These two fundamentally different types of particle movements are *diamagnetic*, those with axes orientation patterns are called *paramagnetic*, *ferromagnetic*, *antiferromagnetic*, *ferromagnetic*, *antiferromagnetic* or *helical*, depending on which pattern of spin-axis orientation is stable under given environmental and chemical circumstances.

Spinning electrons have much larger Magnetic Moments than do spinning nuclei. This is because the small mass of an electron makes it spin much faster than any nuclei. Thus high levels of Reactive Oxygen Species can be generated in the body. Hence the increased EMF in the home such as radios, electric plugs, microwave and conductive ovens, TV set computers, as EMF, especially the magnetic component, interacts with the intricate electrical activities of the central nervous system as synapses which are the core structure that involves the electro-chemical signals that direct the body [80]. Chronic or over exposure to EMF has been found to alter chromosomes and DNA and gene expression [72,73,77,81]. It can also disturb the mitochondrial ADP phosphorylation process – crucially stem cell functioning, and can create apoptosis of neural cells [67,71–75]. The EMF can also influence melatonin [70,78] and in particular create oxidative stress [82–85] which is linked to shrinkage of dendritic spines in the hippocampus [86,87]. All these features appear to be precursors of neurological pathology.

Whilst other environmental influences might well be interacting with the EMF, such as nanoparticles from Petro-chemical pollutants, that can also result in increased in oxidative stress, which is associated with the development of neuro-degenerative disease [34,51–59,71–92].

Hence these relatively new EMF effects extenuate the extant multiple environmental pollutants, albeit at low, and individually, at officially 'safe' levels!

Whilst not forgetting that EMF helps in some conditions low levels of EMF, especially over time, exposure to EMF have also been found to be linked with memory problems [57,90–95]. This apparent inconsistency is highlighted as traumatic EMF, in the sense that electric shocks and head injury have also been associated with neurodegenerative diseases [96–99]. On balance it would appear the pathology occurs with high intensity but short duration and low intensity but long and frequent intensity [99–103] (the Bunsen-Roscoe effect), which might account for the apparent inconsistency of EMF being therapeutic [24–27], not unlike radiotherapy for cancer [84–104]. A key paper on how high gradient EMF affects cell life found that even relatively small

EMF can crucially change the cell membrane and disturb its biological function leading to cell death [105]. One study looked at the preventive role of resveratrol in reducing oxidative stress in a four-year controlled study of long-term occupational exposure to EMF, to find after four years the index group had substantially lower cellular damage than controls [104]. As there are similar new studies from China and Russia does this imply that the safety of workers in the EMF industries is a matter of growing interest?

#### *Electro-MAGNETIC-fields tipping point*

The studies that initially led to our hypothesis was by Hallberg who analysed Swedish national mortality data on Alzheimer's from 1948 until 2014 [59]. The graph on increased Alzheimer's from 1948 to 1988 rose at an angle of 5 degrees but from 1990 to 2014 the curve rose to a 75 degree angle. The researchers linked these changes to increases in background EMF. The second was a small cluster study examining Motor Neurone Disease in a Southern English village to find an eight times the county rate of MND and four times the UK national rate [98]. The methodological problems of cluster studies were readily acknowledged but what was striking was the local geography of the village which was aligned with a busy airport, compounded all the environmental health problems (chemical, solvent, EMF) associated with airports [32,46,48,51,53,55,84,90,107]. On either side of the runway were two large downs. On the West was the airport's radar equipment and on the East were the county commercial mobile masts. The local geography meant that the flight take-off was low for five miles to the village which had an excess of MND patients [102].

There are a range of studies identifying neurological pathology to links with solvents [54], chemicals [2–4]; electronics and IT, [72–84,105] and occupations that include the former [46–52,71,96,101]. Thus this airport, with the relative high density of Petro-chemical, nanoparticles and electro-radiation, brought together in one site key interactive environmental pollutants [102]. Whilst other studies link neurological disorders to airport environments and risks to airline pilot's health [32,105,106].

Taken together it can be seen that there are strong indications of the increased EMF impacting upon human health, both neurological, as well as with some cancers [1,10,71,104,108,109].

However the aetiological issues of neurological disease is complex as quite apart from the genetic-environmental, some studies have found a viral link with neurological disease [110], another with diabetes [111], alcohol being associated with Alzheimer's [112] and the notable rises in allergies over the past two decades [113], whilst an earlier study explored EMF on male reproductive patterns which are known to be falling in many Western developed countries [22].

One very important feature is the role of any under-lying genetic predisposition, which might explain why oxidative stress is associated both with the cancers neurological diseases. This complicates pinning down the precise interactive mechanisms of people living in the same environmental situation but develop different conditions or no obvious pathologies, possibly depending on genetic predispositions [1–3,37,46,48,49,52,54,57,60,64,65,71,90,102,109].

It would be conclusive if we could accurately measure EMF changes in the human environment but all we can do is remind readers of the massive intrusion into our world of EMF devices which really only began in the 1990's.

#### *Discussion of the cautionary principle*

There is little doubt that there has been a marked increase in episodic neurological disease which seems to be a response changing interactive multiple environmental pollution, impacting upon under-lying genetic factors. The question is has the case been made that the EMF might be a key tipping point for this hitherto relatively ignored neurological epidemic?

The answer paradoxically, might be found in how the various national and official authorities have sought greater awareness of the dangers of EMF that are so helpful and convenient to our lives, ranging from mobile phones, PC's to induction cookers [80]. Early official regulations on the safety of EMF in the USA in 2002 were mildly speculative and cautionary [114]. Later in 2006 the Committee on 'Man and Radiation' was acknowledging that there could be possible health problems [115] whilst in 2016 the EU called for greater surveillance and investigation of related health problems of EMF, crucially it acknowledged that there were emerging health problems [116]. Indeed urging an cautionary approach from early to late life and the need for importance of radiation studies of workers [104,106,117–120].

From Rachel Carson in 1968 alerting us to the simple fact that humans are affected by the environment in which they live which is the very driving force of evolution, to present changes.

Recent studies related to ionising radiation related to workers in the nuclear industry whilst focusing upon cancers reasserted the precautionary principle found in the use of the linear-no-threshold (LNT) dose-response model. This points to the risk being related to received doses but acknowledge there are no threshold doses below which there is no risk. This might well be true for background EMF impacting upon long term human health and development [105,113,114,120–124].

To an extent this paper challenges one of the most exciting human developments, the emergence of the universal digital age therefore it may arouse the wrath of possible vested interests. We reiterate, we do not want to stop the modern digital age but make it safer, as the long term effects of being closely surrounded by new compounded levels electro-magnetism are simply unknown but there are symptomatic danger signals.

This study provides sufficient indicative evidence that we need to proceed, guided by the cautionary principle, to re-consider health and safety guidelines in relation to compounded increases in EMF and human health, especially neurological. At the time of writing this has been given greater urgency as charities with Progressive Supranuclear Palsy patients are seeking help under the age of forty, which reflects recent major studies of a cohort of MSA patients mean onset of 37 years [31–33,99]. Such young people with a dementing neurodegenerative disease would have been unknown forty years ago and barely credible thirty years ago. Neurological disease, as with other conditions has a combination of interactive causes but with human neurology, which is essentially an electro-biochemical system, the EMF is likely to play a significant role.

Despite the size of the literary review we returned to Medline for the latest papers on the topic and despite the continuing inconsistencies. There are current papers showing negative associations and one suggesting a placebo effect, with is the reverse of the placebo effect, self-suggestion that something is wrong [124] but the further need for caution has not been ruled out. There is beginning to be research across the Western world showing a growing sense of urgency related to EMF impact upon child and adolescent developing brains [125–127]. Whilst the pre-cautionary measured introduction the use of Resveratrol which appears to reduce oxidative stress and is claimed to be offer some protection against adverse effects of EMF! [104].

The key is to think outside the box and considered what might EMF do to the other existing pollutants in the human environment and the number of years it takes to develop neurodegenerative diseases, as with other classic environmental induced pathology [17,18].

In closing, we take a backward look over just 25 clinical years to consider the rises in the incidence of Autism and Asperger syndrome, Chronic Fatigue Syndrome, ADHD, Early Onset Dementias, rises in the WHO diagnostic categories Nervous Disease Deaths and Alzheimer's and Other Dementia deaths across the Western world, all alongside intensive increases in background environmental pollutants and the now ubiquitous EMF. Part of the problem is that these influences have been slow and insidious and the new digital world, so full of 'good things', perhaps we may need to begin to realise that possibly we have

opened Pandora's Box. There is a need to re-think the modern world's impact upon human health and its epigenetic development, almost matching as it does climate change, which for so long has relatively been denied.

It is stressed that we do not want to 'stop the modern' EMF world, only make it safer. Finally, we close as we began. It is an evolutionary fact that humans evolved within the Earth's electro-magnetic-field and the sun's radiation. If we have too much sun we burn so are we beginning to get too much EMF that stirs up the soup of interactive multiple-pollutants that impact upon human health?

## Conflict of interest

We confirm that none of the authors have either a conflict or vested interest in the study. No was there an external funding for the project.

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